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(54) **AIRCRAFT WINDSHIELD AND METHOD FOR SUSPENDING AIRCRAFT WINDSHIELD**

(71) Applicant: **mitsubishi aircraft CORPORATION**, Aichi (JP)

(72) Inventor: **Keiji Nakashima**, Aichi (JP)

(73) Assignee: **mitsubishi aircraft CORPORATION**, Aichi (JP)

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CPC ..... **B64C 1/1492** (2013.01)

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USPC ..... 29/897.1, 897-897.35, 402.01-402.21, 29/464, 525.01-525.15, 559  
See application file for complete search history.

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*Primary Examiner* — Tien Q Dinh

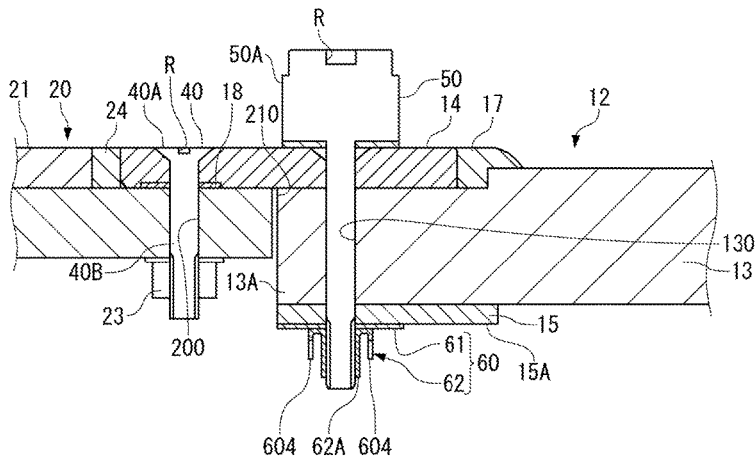
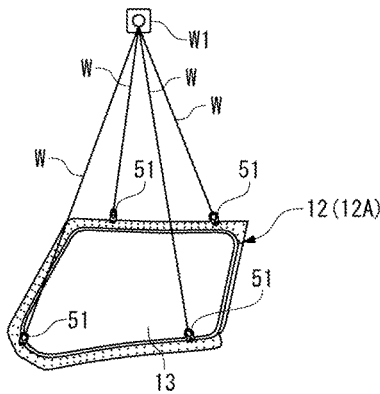
*Assistant Examiner* — Alexander V. Giczynski

(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

A row formed by a plurality of windshield fasteners, which fasten an outboard retainer, a panel, and an inboard retainer of a windshield of an aircraft, along a peripheral edge part of the windshield panel includes a first fastener, which is disposed at a predetermined position, and a pair of second fasteners, which is disposed in alignment with the row, one on each side of the first fastener. A plate, which is fastened along with the windshield panel by the first fastener and the pair of second fasteners, is disposed on the inboard retainer on the inside of the aircraft. The first fastener can be attached to or detached from a fixing nut, which is fixed on the plate, from the outside of the aircraft, and can be replaced with a suspension fastener on which a wire to be mounted on the windshield can be fitted.

**6 Claims, 7 Drawing Sheets**



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FIG. 1A

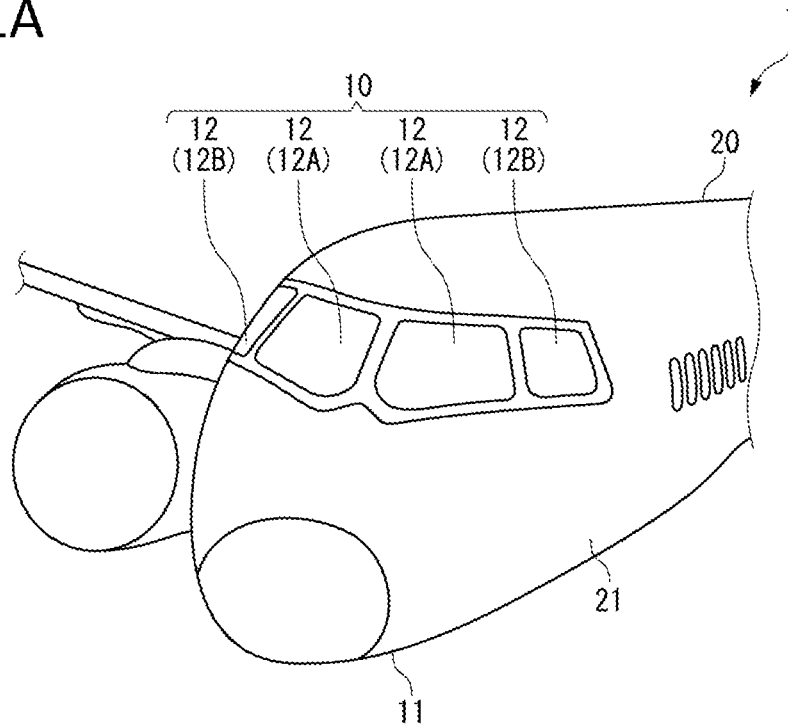


FIG. 1B

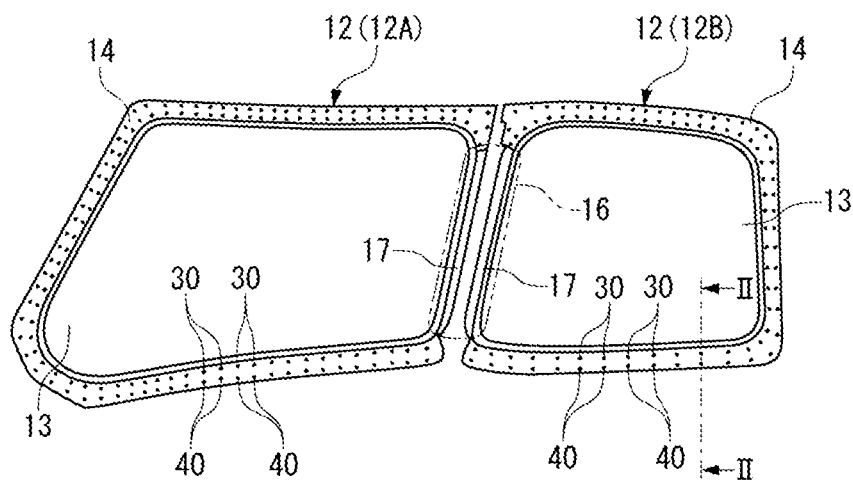




FIG. 3A

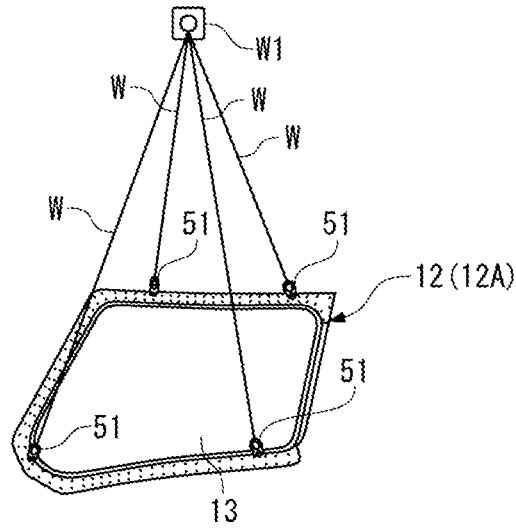


FIG. 3B

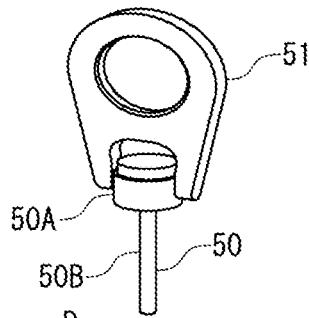


FIG. 3C

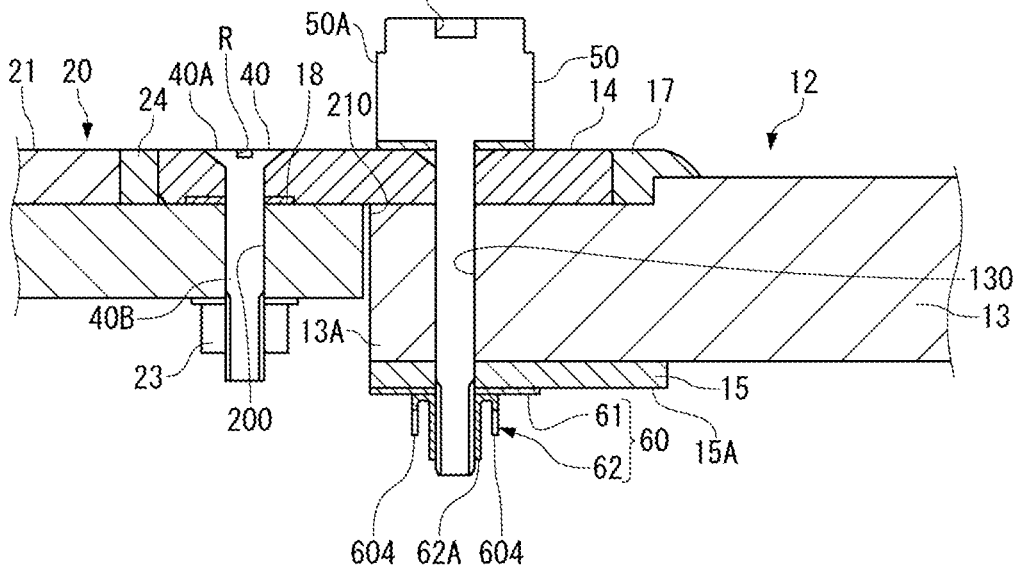


FIG. 4A

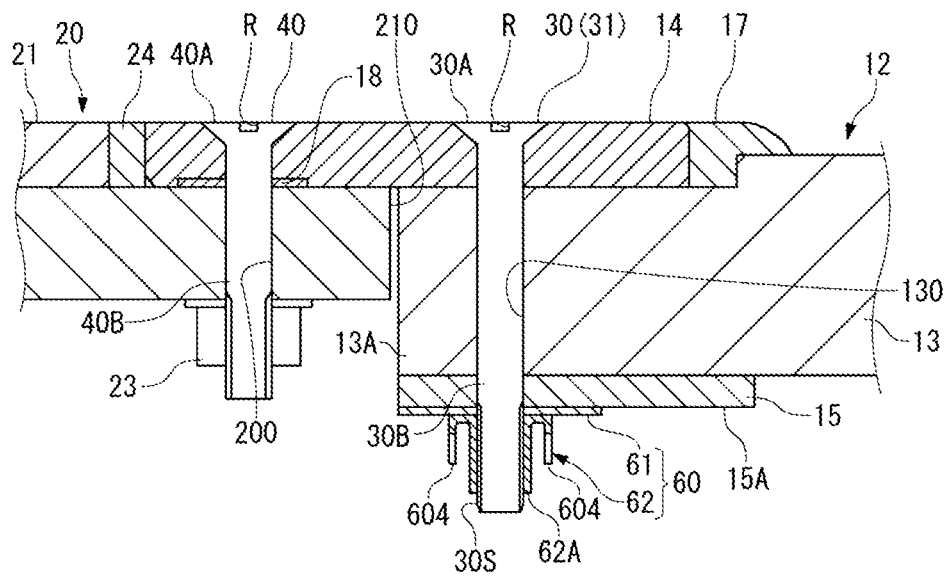


FIG. 4B

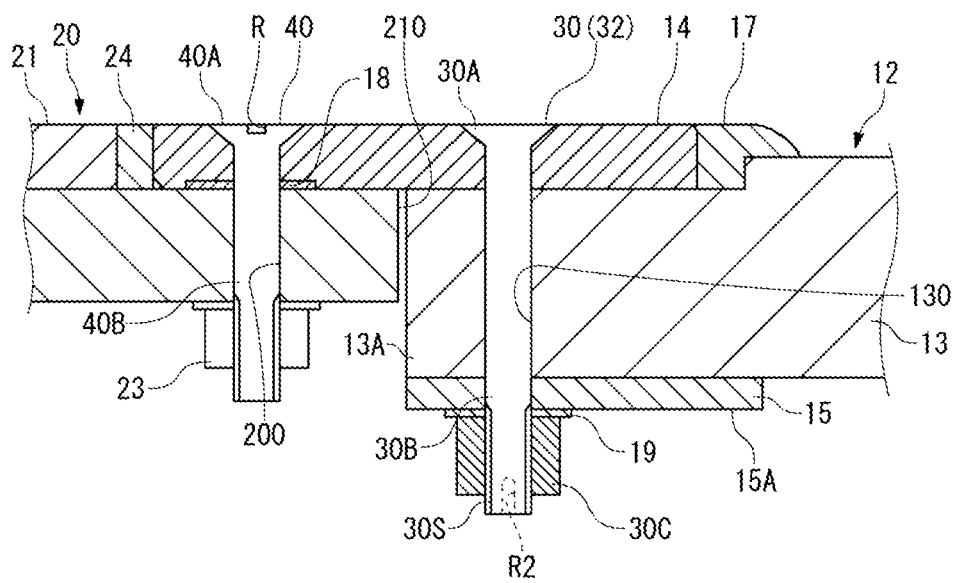




FIG. 6

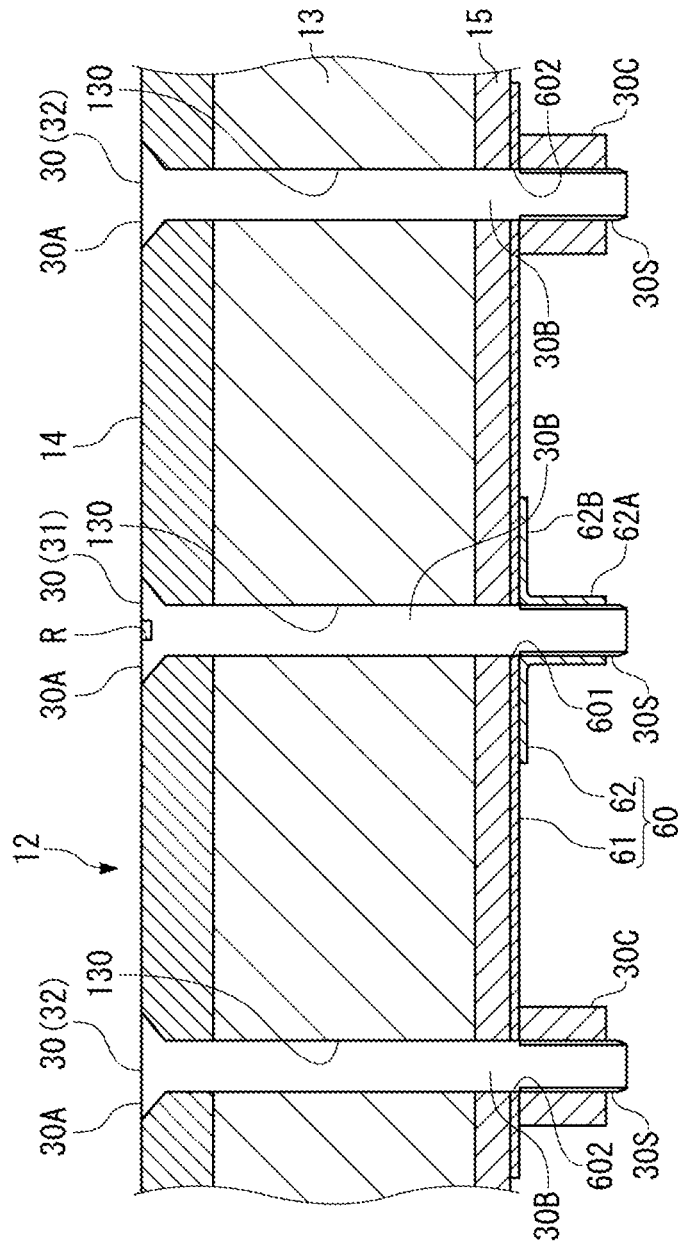
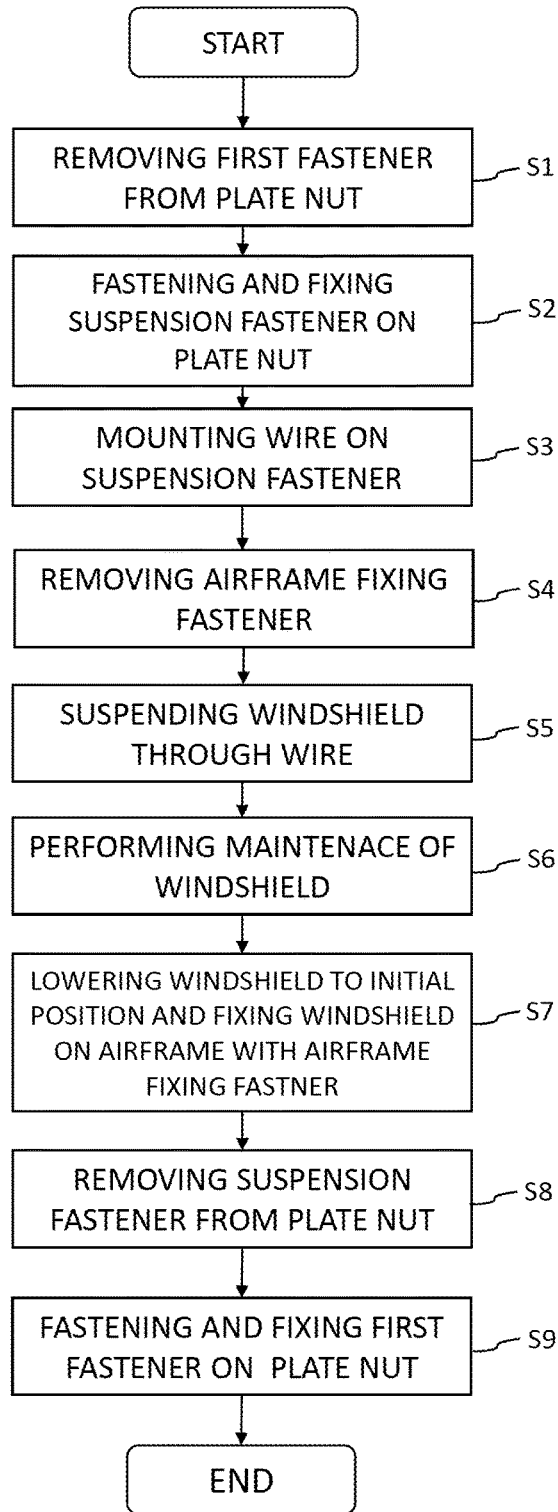


FIG. 7



# AIRCRAFT WINDSHIELD AND METHOD FOR SUSPENDING AIRCRAFT WINDSHIELD

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to a structure of a windshield for suspending a windshield during maintenance of an aircraft and a method for providing a windshield with a lifting component.

### Description of the Related Art

An aircraft windshield is assembled by holding a windshield panel between two retainers, inserting a fastener into a sleeve disposed in the thickness direction of these windshield panel and retainers, and fixing the fastener with a nut as shown in Japanese Patent Laid-Open No. H2-204197, for example. This type of windshield is installed in an airframe by fixing the retainer, which is disposed on the outside of the aircraft, on the airframe with a fastener.

When the windshield is removed from the airframe for maintenance of the windshield, to prevent fall of the windshield, the windshield is suspended through wires mounted at a plurality of positions in the peripheral edge part of the windshield. To securely fix these wires on the windshield, suspension fasteners having a head part on which the wire can be fitted are fixed on the peripheral edge part of the windshield. Bushes for fixing the suspension fasteners are provided in the peripheral edge part of the windshield. These bushes are normally covered with other fasteners having a conical head part, and for maintenance of the windshield, these fasteners are removed and the suspension fasteners are fixed on the bushes.

The bush for fixing the suspension fastener on the windshield is embedded and bonded in the peripheral edge part of the windshield. The present inventors wish to provide a windshield which has a structure for suspending a windshield in a simpler manner without providing the windshield with such a bush.

If the fastener fastened on such a bush is damaged, maintenance is disrupted as the fastener and the bush cannot be easily removed from the windshield.

The present invention aims to provide a simpler structure for suspending an aircraft windshield as well as to improve the maintainability of a windshield.

## SUMMARY OF THE INVENTION

An aircraft windshield of the present invention is a windshield provided in an airframe of an aircraft, the windshield including: a panel forming the windshield; an outboard retainer disposed on the panel on the outside of the aircraft; an inboard retainer disposed on the panel on the inside of the aircraft; a plurality of windshield fasteners which fasten the outboard retainer, the panel, and the inboard retainer; and a plurality of airframe fixing fasteners which fasten the outboard retainer and the airframe.

A row formed by the plurality of windshield fasteners along the peripheral edge part of the panel includes a first fastener disposed at a predetermined position and a pair of second fasteners disposed in alignment with the row, one on each side of the first fastener.

A plate which is fastened along with the panel by the first fastener and the second fasteners is disposed on the inboard retainer on the inside of the aircraft.

The first fastener can be attached to or detached from a fixing nut, which is fixed on the plate, from the outside of the aircraft.

A plurality of fastener groups each composed of the first fastener and the pair of second fasteners are disposed at intervals in the circumferential direction of the panel.

The first fastener in each of the plurality of fastener groups can be replaced with a suspension fastener on which a lifting component to be mounted on the windshield can be fitted.

According to the present invention thus configured, the suspension fastener, on which the lifting component can be fitted, can be fixed on the windshield by disposing the plate with the fixing nut fixed on it on the inboard retainer on the inside of the aircraft, fastening the plate along with the windshield by the first fastener, which can be replaced with the suspension fastener, and the pair of second fasteners, and fixing the suspension fastener in place of the first fastener to the fixing nut. The present invention can provide a simpler structure for suspending a windshield, since it does not require providing the windshield with embedded bushes.

Even if the first fastener, the fixing nut, or the suspension fastener is damaged, the plate and the damaged fastener and the fixing nut can be easily removed from the windshield by removing the pair of second fasteners which fastens the windshield and the plate, so that the maintainability of the windshield can be improved.

In the aircraft windshield of the present invention, it is preferable that the windshield fastener be disposed with its head part directed to the outside of the aircraft; a recess, into which a tool can be inserted, be formed in the head part of the first fastener; and the recess be not formed in the head part of the second fastener.

Then, in the row formed by the windshield fasteners, the first fasteners can be sorted out on the basis of the recess being formed in it, while avoiding mistakenly removing the second fasteners in which no recess is formed.

An aircraft of the present invention includes the above-described windshield.

A method for suspending an aircraft windshield of the present invention includes: a first step of loosening the first fastener from the fixing nut from the outside of the aircraft to remove the first fastener from the windshield; a second step of inserting the suspension fastener into a through-hole of the windshield, into which the first fastener has been inserted, from the outside of the aircraft and fastening the suspension fastener to the fixing nut; a third step of removing the airframe fixing fastener from the outside of the aircraft; and a fourth step of suspending the windshield through the lifting component.

According to the present invention, it is possible to provide a simpler structure for suspending an aircraft windshield as well as to improve the maintainability of a windshield.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a view showing four windshields provided in an aircraft according to an embodiment of the present invention;

FIG. 1B is a view from the outside of the aircraft showing a first windshield and a second windshield provided on the left side of the airframe of the aircraft according to the embodiment of the present invention;

FIG. 2 is a view along the line II-II of FIG. 1B showing a windshield fastener and an airframe fixing fastener;

3

FIG. 3A is a view showing how the windshield is suspended through wires;

FIG. 3B is a view showing a maintenance fastener with a pulling eye, on which a wire W can be mounted, mounted on it;

FIG. 3C is a view showing a state in which the windshield fastener (first fastener) shown in FIG. 4A is replaced with a suspension fastener;

FIG. 4A is a view along the line IVa-IVa of FIG. 5B;

FIG. 4B is a view along the line IVb-IVb of FIG. 5B;

FIG. 5A is a view showing the windshield from the outside of the aircraft;

FIG. 5B is an enlarged view showing a plate nut device disposed on the windshield on the inside of the aircraft;

FIG. 6 is a view along the line VI-VI of FIG. 5B showing the first fastener located at the center of the plate nut device and second fasteners located at both ends of the plate nut device; and

FIG. 7 is a view showing the maintenance procedure of the windshield.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, an aircraft windshield according to an embodiment of the present invention will be described with reference to the accompanying drawings.

As shown in FIGS. 1A and 1B, a nose 11 of an aircraft 1 is provided with a windshield device 10. The windshield device 10 is composed of first windshields 12A, 12A located on the front side in the traveling direction of the aircraft 1 and second windshields 12B, 12B located on the left and right sides of these first windshields 12A, 12A. These windshields 12B, 12A, 12A, 12B are disposed in a left-right symmetry to the axis of the fuselage of the aircraft 1.

These four windshields 12B, 12A, 12A, 12B cover one opening 210 (FIG. 2) formed in a frame 22 of an airframe 20. The frame 22 supports a skin 21 from the back side (FIG. 2). A nose part of the airframe 20 includes, as structural members, the frame 22, the skin 21, and stringers (not shown). These members can be formed from a metal material such as an aluminum alloy or a fiber-reinforced resin containing reinforcing fibers such as glass fibers or carbon fibers.

In the following, when the windshields 12B, 12A, 12A, 12B are not differentiated from one another, each of them is simply called a windshield 12.

The number of windshields 12 is not limited to four but may be an arbitrary number.

The windshield 12 has the strength to sufficiently withstand various loads applied to it during a flight, such as a load due to the pressure difference between the pressure inside the aircraft and the pressure outside the aircraft, an aerodynamic load due to air resistance during a flight, or an impact load due to collision with a bird etc.

As shown in FIG. 1B and FIG. 2, the windshield 12 includes, as major components, a transparent windshield panel 13, an outboard retainer 14 which is disposed on a surface of a peripheral edge part 13A of the windshield panel 13 on the outside of the aircraft; and an inboard retainer 15 which is disposed on a surface of the peripheral edge part 13A on the inside of the aircraft.

While not shown in detail, the windshield panel 13 is configured with an impact buffer layer and an anti-icing conductive layer held between an outer panel disposed on the outside of the aircraft and an inner panel disposed on the inside of the aircraft. In this embodiment, the outer panel and

4

the inner panel are formed from a glass material, but these panels can also be formed from an acrylic resin.

The configuration of the windshield panel 13 is not limited to this embodiment but can be appropriately changed.

As shown in FIG. 1B, the outboard retainer 14 is formed so as to be disposed in each of the first windshield 12A and the second windshield 12B along all the sides except for the side located on the border between the first windshield 12A and the second windshield 12B. On the border between the first windshield 12A and the second windshield 12B, a border retainer 16 (indicated by the two-dot chain line in FIG. 1B) having a linear shape is disposed along the side of each of the first windshield 12A and the second windshield 12B. The border retainer 16 corresponds to the outboard retainer shared by adjacent windshields 12.

In view of weight reduction, an aluminum alloy can be preferably used as the material of the outboard retainer 14, the border retainer 16, and the inboard retainer 15.

As shown in FIG. 2, the outboard retainer 14 extends from the peripheral edge part 13A of the windshield panel 13 toward the outside. The inside in the width direction of the outboard retainer 14 is fixed on the peripheral edge part 13A of the windshield panel 13, while the outside in the width direction of the outboard retainer 14 is fixed on the airframe 20.

The clearance between the inner peripheral edge of the outboard retainer 14 and the outer peripheral edge of the surface layer of the windshield panel 13 is continuously sealed by a seal 17. The clearance between the back surface of the outboard retainer 14 and the front surface of the frame 22 is sealed by a seal 18. The clearance between the outer peripheral edge of the outboard retainer 14 and the end surface of the skin 21 is sealed by a seal 24. The pressure inside the aircraft is maintained by these seals 17, 18, 24. Both the seals 17, 24 of this embodiment are formed by packing the part to be sealed with a sealant material having fluidity and curing the sealant material.

The inboard retainer 15 is disposed along the surface of the peripheral edge part 13A of the windshield panel 13 on the inside of the aircraft. The inboard retainer 15 is formed annularly along the peripheral edge part 13A of the windshield panel 13.

The windshield 12 is assembled by holding the windshield panel 13 between the outboard retainer 14 and the inboard retainer 15 from the outside and the inside of the aircraft and fixing them with windshield fasteners 30.

The windshield fastener 30 is a fastening bolt integrally having a head part 30A and a shank part 30B, and constitutes fastening means along with a nut 30C disposed on the inside of the aircraft. The head part 30A, which constitutes an aerodynamic surface, has a conical shape and is housed in a bowl-shaped countersunk formed in the outboard retainer 14. A screw 30S is formed on the leading end side of the shank part 30B.

The windshield fastener 30 and the nut 30C can be formed from stainless steel, a titanium alloy, etc. A washer 19 is inserted between the surface of the inboard retainer 15 on the inside of the aircraft and the nut 30C.

The windshield fastener 30 penetrates the windshield 12 in the thickness direction in the order of the outboard retainer 14, the windshield panel 13, and the inboard retainer 15 from the outside of the aircraft. A seal (not shown) may be provided between the outboard retainer 14 and the windshield panel 13 and between the windshield panel 13 and the inboard retainer 15.

A through-hole **130**, into which the windshield fastener **30** is inserted, is formed in these outboard retainer **14**, windshield panel **13**, and inboard retainer **15**. The windshield fastener **30** is inserted into a sleeve (not shown) disposed inside the through-hole **130**. The windshield fastener **30** is fixed by being fastened to the nut **30C**. The windshield fastener **30** is fastened with a tool from the inside of the aircraft.

Since the windshield **12** once assembled is not supposed to be disassembled, the outboard retainer **14**, the windshield panel **13**, and the inboard retainer **15**, which are the components of the windshield **12**, can be connected permanently with one another. While it is acceptable to use a rivet instead of the fastening bolt for assembling the windshield **12**, in this embodiment, the fastening bolt is adopted, for which a material having a high specific strength such as stainless steel or a titanium alloy can be used and which has high reliability. As the fastening bolt, one intended for applications based on permanent connection is preferably used.

On the other hand, in order to remove the windshield **12** from the airframe **20** during maintenance, the windshield **12**, the airframe **20**, and the outboard retainer **14** interposed therebetween are not connected permanently with one another but assembled through detachable airframe fixing fasteners **40**.

Similarly to the windshield fastener **30**, the airframe fixing fastener **40** is a fastening bolt integrally having a head part **40A** and a shank part **40B**, and the head part **40A** has a conical shape.

The airframe fixing fastener **40** is located further on the outside in the width direction in the outboard retainer **14** than the position of the windshield fastener **30**. A plate nut **23**, on which this airframe fixing fastener **40** is fastened, is provided in the frame **22**. A recess R, into which a tool can be inserted, is formed in the head part **40A** so that the airframe fixing fastener **40** can be fastened from the outside of the aircraft.

The frame **22** is disposed so as to surround the opening **210** of the skin **21**.

As shown in FIG. 1B, a large number of windshield fasteners **30** are disposed at intervals in the circumferential direction on the inner peripheral side of the outboard retainer **14**. A large number of airframe fixing fasteners **40** are disposed at intervals in the circumferential direction on the outer peripheral side of the outboard retainer **14**.

As will be described later, a row formed by the plurality of windshield fasteners **30** includes a first fastener **31**, which is disposed at a predetermined position, and a pair of second fasteners **32, 32**, which is disposed one on each side of the first fastener **31** in alignment with the row formed by the windshield fasteners **30**.

Both the above-described fasteners **30, 40** are required to have a sufficient strength against a load applied to the windshield **12** during a flight. The material, the diameter, and the fastening torque of the fasteners **30, 40** are properly determined in order to secure the strength. The number and the arrangement of the fasteners **30, 40** are also properly determined.

The above-described outboard retainer **14**, inboard retainer **15**, and border retainer **16** are covered by interior members provided in a cockpit and not exposed to the inside of the aircraft. The interior members include a liner covering the structural members such as the frame **22** and the skin **21**, a panel on which instruments are disposed, and various other members for improving the visual appearance or buffering impact.

The configuration for suspending the windshield **12** during maintenance will be described as the feature of this embodiment.

In order to prevent fall of the windshield **12** which has been removed from the airframe **20**, before removing the windshield **12** from the airframe **20**, one ends of wires W are each mounted at several positions (four positions in this example) in the peripheral edge part of the windshield **12**, and a metal fitting W1 which bundles the other ends of the wires W is set on an arm of a crane (not shown) as shown in FIG. 3A. Thus, as the windshield **12** is suspended by the crane without falling even when the windshield **12** is separated from the airframe **20**, the airframe fixing fastener **40** is removed using a tool etc. from the outside of the aircraft. Then, maintenance or replacement with a new one of the windshield **12** is performed.

In this embodiment, the wire W is mounted at four positions of the windshield **12**.

In order to mount the wire W on the windshield **12**, a suspension fastener **50** having a pulling eye **51**, on which the wire W can be fitted, in its head part **50A** is fixed on the windshield **12** as shown in FIG. 3B. The recess R (FIG. 3C), into which a tool can be inserted from the outside of the aircraft, is formed in the head part **50A** of the suspension fastener **50**. The material, the diameter, etc. of the suspension fastener **50** are properly determined so that the suspension fastener **50** has a sufficient strength against a load acting on it while the windshield **12** is suspended. The same number of suspension fasteners **50** as the number of the wires W to be mounted on the windshield **12** is required.

Dedicated holes and bushes for fixing each of the suspension fasteners **50** are not provided in the windshield **12**. All the suspension fasteners **50** are inserted into the through-holes **130** in place of the windshield fasteners **30** as shown in FIG. 3C. Then, the suspension fasteners **50** are fixed on a plate nut device **60** provided in the inboard retainer **15**.

The windshield fasteners **30** having the head part **30A** in which the recess R, into which a tool can be inserted, is formed as shown in FIG. 4A is used as the windshield fasteners **30** to be replaced with the suspension fasteners **50** so that the windshield fasteners **30** can be attached or detached from the outside of the aircraft. FIG. 4B shows the windshield fastener **30** which cannot be attached or detached from the outside of the aircraft, and this windshield fastener **30** has no recess R in the head part **30A** (same as the windshield fastener **30** of FIG. 2).

Hereinafter, the windshield fastener **30** having the recess R and attachable and detachable from the outside of the aircraft (FIG. 4A) will be called a first fastener **31**, while the windshield fasteners **30** which cannot be attached or detached from the outside of the aircraft (FIG. 4B) will be called a second fastener **32**.

In case it is necessary to remove the second fastener **32**, a recess R2 (indicated by the dashed line in FIG. 4B), into which a tool can be inserted, is formed, for example, at the leading end of the shank part **30B** of the second fastener **32**, while no recess R for inserting the tool is formed in the head part **30A** of the second fastener **32**. Therefore, the second fastener **32** cannot be removed at least from the outside of the aircraft.

The first fastener **31** (FIG. 4A) has the recess R formed in the head part **30A**, and a fastening bolt equal to or higher than the second fastener **32** in material strength, shearing strength, tensile strength, etc. can be used as the first fastener **31**.

At the time when the first fastener **31** is removed from the windshield **12** by inserting a tool into the recess R and the

suspension fastener **50** is fixed on the windshield **12** in place of the first fastener **31**, the airframe fixing fastener **40** is not yet removed and the windshield **12** is fixed on the airframe **20**. The back side of the windshield **12** is covered with the interior members inside the cockpit, and unless the interior members are removed or partially destroyed, the nut **30C** cannot be pressed with a tool by exposing the back side of the windshield **12**.

In this embodiment, to fasten the first fasteners **31** simply by working from the outside of the aircraft, the plate nut device **60** is provided on the inboard retainer **15**. The plate nut device **60** is disposed in the space between the inboard retainer **15** and the interior members.

This plate nut device **60** is used for fixing the first fastener **31** as well as for fixing the suspension fastener **50**.

As shown in FIG. 5A, the plate nut device **60** is provided in the peripheral edge part of the windshield **12** at a plurality of positions (four positions in this example) at a distance from one another in the circumferential direction. The positions of the plate nut devices **60** correspond to the positions of the first fasteners **31**. It is preferable to select the positions of the first fasteners **31** such that the windshield **12** can be stably suspended.

The first fastener **31** constitutes a fastener group F along with the pair of second fasteners **32, 32** which is disposed one on each side of the first fastener **31** in alignment with the row formed by the windshield fasteners **30** along the peripheral edge part of the windshield panel **13**.

As shown in FIG. 5B and FIG. 6, each plate nut device **60** includes a support plate **61** disposed on a surface **15A** of the inboard retainer **15** on the inside of the aircraft and a plate nut **62** fixed in a central part of the surface of a support plate **61** on the inside of the aircraft.

The support plate **61** extends over a region including one fastener group F.

On both sides of the support plate **61** in the length direction, a second through-hole **602** through which the second fastener **32** is passed is formed as shown in FIG. 6. At the center of the support plate **61** located between these second through-holes **602, 602**, a first through-hole **601** through which the first fastener **31** is passed is formed.

The support plate **61** is fastened along with the windshield panel **13** by the first fastener **31** and the pair of second fasteners **32, 32**.

The plate nut **62** includes a fixing nut **62A** and a plate **62B** through which the fixing nut **62A** is fixed on the support plate **61**. The plate **62B** is fixed on the support plate **61** at two positions through rivets **603** (FIG. 5B). In the plate **62B**, a pair of reinforcing ribs **604, 604** rising from the end edge of the plate **62B** is formed along the length direction of the support plate **61**.

It is preferable that the plate nut **62** be formed from a metal material having a high specific strength such as stainless steel or a titanium alloy. In contrast, it is preferable that the support plate **61** be formed from a lightweight aluminum alloy etc.

The fixing nut **62A** forms a hole which communicates with the first through-hole **601** of the support plate **61**.

When assembling the windshield **12**, for the first fasteners **31** and the second fasteners **32, 32** constituting the fastener group F, the support plate **61** of the plate nut device **60** is interposed between the inboard retainer **15** and the nut **30C**. Then, by fastening the second fastener **32** to the nut **30C**, the windshield **12** is assembled and at the same time the plate nut device **60** is fixed on the windshield **12**.

The first fastener **31** can be fastened to the fixing nut **62A** of the plate nut device **60** from the outside of the aircraft

using a tool which is inserted into the recess R. The support plate **61** is fixed on the inboard retainer **15** at two points at which the second fasteners **32, 32** are located, and the plate nut **62** is also fixed on the support plate **61** at two points through the rivets **603, 603**, so that rotation of the plate nut **62** relative to the windshield **12** is restricted. Therefore, the first fastener **31** is fastened to the fixing nut **62A** even when the fixing nut **62A** is not pressed with a tool from the inside of the aircraft so as not to rotate when fastening the first fastener **31** to the fixing nut **62A**.

Since the sufficient rigidity of the plate nut **62** against the load acting on it during fastening of the first fastener **31** is secured by the reinforcing ribs **604, 604** of the plate nut **62**, the first fastener **31** can be securely fastened to a specified torque.

Next, the maintenance procedure of the windshield **12** will be briefly described with reference to FIGS. 3A, 3B, 3C and FIG. 7.

In order to prevent fall of the windshield **12** during maintenance, it is necessary to mount the wires W on the windshield **12** as shown in FIG. 3A before removing the windshield **12** from the airframe so that the windshield **12** can be suspended.

For this purpose, first, the first fasteners **31** are loosened from the fixing nuts **62A** of the plate nut devices **60** to remove the first fasteners **31** (step S1).

Here, since the head part **30A** of the second fasteners **32** has no recess while the head part **30A** of the first fasteners **31** has the recess R, it is possible to easily sort out the first fasteners **31** from the row of the large number of windshield fasteners **30** on the basis of the presence or the absence of the recess R, and to loosen the first fasteners **31** from the plate nuts **62** by inserting a tool into the recess R to remove the first fasteners **31**. It is also possible to avoid mistakenly removing the second fasteners **32**, which have no recess R, from the windshield **12**.

Next, the suspension fasteners **50** are inserted into the same through-holes **130** into which the removed first fasteners **31** have been inserted into, and the suspension fasteners **50** are fastened and fixed to the fixing nuts **62A** of the plate nuts **62** (step S2).

Subsequently, the pulling eyes **51** (FIG. 3B) are mounted on the head parts **50A** of the suspension fasteners **50**, and the wires W are mounted on the pulling eyes **51** and a hook (not shown) of the crane (step S3).

Thus, now that the windshield **12** is ready to be suspended, all the airframe fixing fasteners **40** which fix the windshield **12** on the airframe **20** are removed (step S4). Meanwhile, the border retainer **16** is also removed from the windshield **12**.

Then, the windshield **12** is lifted from the airframe **20** by steering the arm of the crane, and the windshield **12** is suspended through the wires W (step S5). In the same position, or after the windshield **12** is lowered onto a maintenance stand, maintenance of the windshield **12** is performed (step S6).

When maintenance of the windshield **12** is completed, the windshield **12** is lowered to the initial position by the crane, and the windshield **12** is fixed on the airframe **20** with the airframe fixing fasteners **40** (step S7).

Further, the wires W and the pulling eyes **51** are removed from the suspension fasteners **50**, and the suspension fasteners **50** are loosened from the fixing nuts **62A** of the plate nut devices **60** and removed from the windshield **12** (step S8).

Finally, the first fasteners **31** are inserted into the through-holes **130** into which the suspension fasteners **50** have been

inserted, and the first fasteners **31** are fastened and fixed to the fixing nuts **62A** (step **S9**). This completes the series of operations related to maintenance of the windshield **12**.

Since all this series of operations can be performed from the outside of the aircraft, there is no need to place personnel inside the cockpit. Of course, there is no need to remove or partially destroy the interior members either.

According to the embodiment having been described above, the suspension fastener **50** can be fixed on the windshield **12** by disposing the support plate **61**, on which the fixing nut **62A** is fixed, on the inboard retainer **15** on the inside of the aircraft, fastening the support plate **61** along with the windshield **12** by the first fastener **31**, which can be replaced with the suspension fastener **50**, and the pair of second fasteners **32, 32**, and fixing the suspension fastener **50** in place of the first fastener **31** to the fixing nut **62A**. This embodiment provides a simpler structure for suspending the windshield **12** without the need for providing the windshield **12** with embedded bushes.

Moreover, according to the present invention, compared with the configuration in which the first fastener **31** and the suspension fastener **50** are fastened to bushes embedded and bonded in the windshield panel **13**, the maintainability in the case where the fastener is damaged can be improved.

If the first fastener **31** or the suspension fastener **50** fixed on the bush is damaged, since these fasteners cannot be easily removed from the windshield **12**, maintenance of the windshield **12** is disrupted. It is difficult to forcibly remove the fasteners and the bushes from the windshield **12** so as to avoid damage to the members provided near the bush. Therefore, it is sometimes necessary to replace the windshield panel **13** with a new one.

In this embodiment, by contrast, even if the first fastener **31** or the suspension fastener **50** is damaged, there is no need to replace the windshield panel **13** but only the first fastener **31** or the suspension fastener **50** needs to be replaced.

Even if the support plate **61** or the plate nut **62** of the plate nut device **60** is damaged, the plate nut device **60** can be replaced with a new one.

According to this embodiment, since the through-hole **130** is shared by the windshield fastener **30**, which integrally assembles the components of the windshield **12**, and the suspension fastener **50**, it is not necessary to provide a dedicated hole, into which the suspension fastener **50** is inserted, in the windshield **12**. If a dedicated hole is to be provided, in order to guarantee the strength and rigidity of the windshield **12**, it is necessary to determine the suspension positions of the windshield **12** in an early stage of development of an aircraft, and to design the windshield **12** in consideration of various factors including the positions of the through-holes **130** into which the windshield fasteners **30** are inserted, the specifications of the windshield fastener **30**, the specifications of the outboard retainer **14**, the windshield panel **13**, and the inboard retainer **15**, and the specifications of the airframe fixing fastener **40**.

In this embodiment, the suspension fastener **50** can be fixed on the windshield **12**, without requiring any processing on the windshield panel **13**, by determining several pieces of the windshield fasteners **30** to serve as the first fasteners **31** to be replaced with the suspension fasteners **50** in an arbitrary stage of development, and providing the plate nut device **60**, on which the first fastener **31** is fixed, on the inboard retainer **15** on the inside of the aircraft.

Since a fastener having a strength equal to or higher than that of the second fastener **32** is used as the first fastener **31**, no additional strength test is required. It is easy to increase

the number of suspension positions of the windshield **12**, for example, from three to four positions.

In addition, it is possible to make a selection of the configurations presented in the above-described embodiment or appropriately change the configurations into other configurations within the scope of the present invention.

While in the above-described embodiment the plate nut **62**, which has the fixing nut **62A** to which the first fastener **31** and the suspension fastener **50** are fixed, and the support plate **61** are fixed with the rivets **603**, the fixing nut **62A** can be integrally formed in the support plate **61**.

The configuration which allows the first fastener **31** and the suspension fastener **50** to be attached or detached from the outside of the aircraft is not limited to the recess formed in the top surface of the head part. In another configuration, for example, the outer periphery of the head part may be formed into a polygonal shape, with which a tool can engage, so that the fasteners can be attached or detached from the outside of the aircraft.

What is claimed is:

**1.** An aircraft windshield provided in an airframe of an aircraft, the windshield comprising:

a panel forming the windshield;  
an outboard retainer disposed on the panel on the outside of the aircraft;

an inboard retainer disposed on the panel on the inside of the aircraft;

a plurality of windshield fasteners which fasten the outboard retainer, the panel, and the inboard retainer; and  
a plurality of airframe fixing fasteners which fasten the outboard retainer and the airframe, wherein

a row formed by the plurality of windshield fasteners along a peripheral edge part of the panel, includes a plurality of fastener groups, wherein each fastener group includes a first fastener disposed at a predetermined position and a pair of second fasteners disposed in alignment with the row, one on each side of the first fastener, and wherein each fastener group is disposed at intervals along a circumference of the panel,

a plate corresponding to each fastener group, wherein the plate is fastened to the panel by the first fastener and the pair of second fasteners of the corresponding fastener group, is disposed on the inboard retainer on the inside of the aircraft, the plate comprises a fixing nut that is fixed at the center of the plate and a primary through-hole coincident with the fixing nut and a pair of secondary through-holes wherein each secondary through-hole is positioned at an opposite side of the fixing nut and wherein the pair of second fasteners is inserted into the pair of secondary through-holes,

the first fastener is attached to the fixing nut from the outside of the aircraft,

at least one second fastener of the pair of second fasteners of each fastener group is fastened to a removable nut, wherein the removable nut is not fixed with respect to the plate, and

the first fastener in each fastener group is configured to be detached from the fixing nut and can be replaced with a suspension fastener on which a lifting component to be mounted on the windshield can be fitted.

**2.** The aircraft windshield according to claim **1**, wherein each windshield fastener of the plurality of windshield fasteners comprises a head part, and each windshield fastener is disposed with its head part directed to the outside of the aircraft,

a recess, into which a tool can be inserted, is provided in the head part of the first fastener, and

11

the recess is not provided in the head part of the second fastener.

3. An aircraft comprising the aircraft windshield according to claim 1.

4. An aircraft comprising the aircraft windshield according to claim 2.

5. A method for suspending the aircraft windshield according to claim 1 with a lifting component, including:

loosening the first fastener of each fastener group from the corresponding fixing nut from the outside of the aircraft;

removing the first fastener of each fastener group from the corresponding primary through-hole of the windshield;

inserting one of the suspension fasteners into the corresponding primary through-hole of the windshield from the outside of the aircraft and fastening the one suspension fastener to the corresponding fixing nut;

12

removing the airframe fixing fasteners from the outside of the aircraft; and

suspending the windshield with the lifting component.

6. A method for suspending the aircraft windshield according to claim 2 with a lifting component, including:

loosening the first fastener of each fastener group from the corresponding fixing nut from the outside of the aircraft;

removing the first fastener of each fastener group from the corresponding primary through-hole of the windshield;

inserting one of the suspension fasteners into the corresponding primary through-hole of the windshield from

the outside of the aircraft and fastening the one suspension fastener to the corresponding fixing nut;

removing the airframe fixing fasteners from the outside of the aircraft; and

suspending the windshield with the lifting component.

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